forms assumed by crystals under different conditions. Petrologists have long been familiar with the tendency of crystals developing in a viscid medium to excessive growth in one or more directions. Felspar is a familiar instance, the lath-like forms which it frequently assumes being due to elongation along one axis (x), the length of prisms measured along this axis often exceeding by ten times that along the axis y or z. The cause of this need not now be discussed; it will be sufficient to add that the phenomenon is not special to felspar, but is of quite general occurrence. With this tendency is connected the origin of curvilinear forms. We may consider the molecules forming the growing face of a long prism; the spheres of influence of these lie half within and half without the substance of the crystal. Considering this influence as attractive (directly or indirectly), we may say that the attraction of the molecules leading to further deposition is one-half their total attraction. If now from the face we pass to the edge between two faces at right angles, only one-quarter of the sphere will be immersed, and the attraction may be spoken of as three-quarters of the whole; while if from the edge we pass to a corner, only one-eighth is immersed, and the attraction becomes seven-eighths. From this it follows that growth should be more rapid at the edges than over the surface of the face, and still more rapid at the corners. In accordance with this we find young growing prisms in a viscid medium increasing so rapidly at the edges as to leave a space in and about the axis filled with the medium in a non-crystalline state. Indeed, a viscid medium is not necessary; hollow prisms are of common occurrence whenever crystallization takes place with rapidity. Further, in quite embryonic crystallites, Vogelsang figures elongated prism-like forms, in which the four corners are produced parallel to the long axis into processes resembling spines. There is an additional reason pointed out to me by Prof. Fitzgerald why growth should be more rapid at the edges and corners than over the general surface, and that is that these parts are more exposed to molecular bombardment.

If crystals are more readily built up along edges and corners, we should expect them to be more readily unbuilt in these regions, and this is in accordance with observation; the zonal felspars of igneous rocks, in the formation of which intervals of solution have alternated with periods of growth, usually present, in the outlines of each resulting envelope, rounded corners.

The influence of corners is well seen in some glassy rocks where small prisms of felspar (andesite) may be observed, with five or six slenderer but longer prisms springing from a corner in radiate divergence.

From this it is but a step to curvilinear growth. Let a prism tend to rapid rectilinear growth, and any check immediately in front will lead to a forward growth from a corner in a slightly different direction; even the competition of molecules for this centre of attraction may by overcrowding bring about this result, and thus both branching and curvilinear forms may arise. This is beautifully exemplified in the spherulites of many igneous rocks, where we find in the centre of a radiately crystallized sphere a long prism of felspar serving as a nucleus, and from the *ends* of this slender, almost linear, prisms diverge towards a spherical surface which by repeated branching and associated curving they everywhere reach, leaving about the sides of the nucleus a spherical space almost devoid of crystal structure. The whole arrangement in median longitudinal section presents a remarkable resemblance to the lines of force as shown by iron-filings about a bar magnet.

Evidently in rapid crystallization with a tendency to linear growth, divergence may be repeated at such frequent intervals as to produce forms which to the unaided eye appear to be continuous curves.

SOCIETIES AND ACADEMIES.

LONDON.

Mathematical Society, December 8.—Mr. A. B. Kempe, F.R.S., President, in the chair.—The following communications were made:—On a theorem in differentiation, and its application to spherical harmonics, by Dr. Hobson.—On Cauchy's condensation test for the convergency of series, by Prof M. J. M. Hill. Cauchy's condensation test for the convergency of series is as follows:—If $f(n)$ be positive for all values of n, and constantly decrease as n increases, then the series $\Sigma f(n)$ and $\Sigma a^n f(a^n)$ are both convergent or both divergent, where a is any positive integer not less than 2. There is a clear reason why a cannot be unity, for then $\Sigma a^n f(a^n) = \Sigma f(1)$, which is always infinite. It is proved in Chrystal's "Algebra" that the theorem is also true if a have any positive fractional value not less than 2, see part 2, chapter xxvi., § 6, cor. 1. The proof there given when a lies between the consecutive positive integers p and $p + 1$ is based on Cauchy's proof for the two cases $a = p$ and $a = p + 1$. But this proof will not apply when $1 < a < 2$, because Cauchy's proof will not apply when $a = 1$. Yet it does not seem possible to assign a reason for excluding values of a between 1 and 2, for Cauchy's method appears to depend on this—viz. that for increasing values of n the expression $f(a^n)$ occupies more and more advanced positions amongst the terms of the series $\Sigma f(n)$; but this is possible if $1 < a < 2$, as well as when $a > 2$. If $a \leqq 1$, then this is no longer true. The problem then considered in this paper is so to recast the proof for fractional values of a as not to exclude the case $1 < a < 2$. The complete theorem will then stand thus:—If $f(n)$ be positive for all values of n, and constantly decrease as n increases, then the series $\Sigma f(n)$ and $\Sigma a^n f(a^n)$ are both convergent or both divergent if $a > 1$. The demonstration depends on the following theorems.

I. If $\Sigma a^n f(a^n)$ be convergent, then—

$$\sum_{n=1}^{n=\infty} f(n) < f(1) + \ldots + f(t_s) + (a - 1 + a^{-s}) \left[\sum_{n=1}^{n=\infty} a^n f(a^n) - \sum_{n=1}^{n=s-1} a^n f(a^n) \right]$$

where s is any integer so large that

$$a^{s+1} - a^s > 1,$$

and t_s is the greatest integer in a^s, a being greater than 1.

II (A). If $\Sigma a^n f(a^n)$ be divergent, and if $a^n f(a^n)$ diminish as n increases beyond a certain value, then

$$\sum_{n=1}^{n=\infty} f(n) > f(1) + \ldots + f(t_s) + (1 - a^{-1} - a^{-s-1}) \left[\sum_{n=1}^{n=\infty} a^n f(a^n) - \sum_{n=1}^{n=s} a^n f(a^n) \right]$$

II (B.) If $\Sigma a^n f(a^n)$ be divergent, and if $a^n f(a^n)$ do not diminish as n increases beyond a certain value, then—

$$\sum_{n=1}^{n=\infty} f(n) > \sum_{n=1}^{n=s} f(n) + \sum_{n=s+1}^{n=\infty} An^{-1},$$

where s is an integer taken large enough, and A is some finite quantity.—Additional note on secondary Tucker circles, by Mr. J. Griffiths.—Notes on determinants, by Mr. J. E. Campbell. In accordance with the late Prof Smith's notation, a determinant of the p^{th} class may be written

$$| a_{ijk} \cdots |$$

The fact that a determinant of the second class (an ordinary determinant) is not altered if the vertical columns be written horizontally is expressed by the identity

$$| a_{ij} | = | a_{ji} |$$

For determinants of higher class it is known that any of the suffixes can be interchanged, except the first: and if the class be even, the first suffix can also be interchanged with any other, but for determinants of odd class this is not true. By considering a cubic determinant as an ordinary determinant in alternate numbers, the author tries to explain this essential distinction between determinants of odd and even classes. If the element $a_{pqr\ldots} = -a_{qpr\ldots}$, and $a_{ppr} = 0$, the determinant is called skew symmetrical. It is easily seen that skew symmetrical determinants of even class and odd degree vanish identically. This is analogous to the well-known theorem in ordinary determinants; but there is no corresponding analogue to the theorem that skew symmetrical determinants of the second class and even degree are perfect squares. The reasoning which establishes these propositions does not apply to skew symmetrical determinants of odd class. By a different method it is shown that they vanish identically whether the class be even or odd. It is next shown that if we form any determinant of even class $2p$ from $2p$ ordinary determinants, in a manner analogous to that in the rule for the multiplication of two ordinary determinants, the determinant so formed is the product of the $2p$ determinants; and if any determinant of odd class $2p + 1$ is formed from $2p + 1$ ordinary determinants, the determinant so formed is the product of the last $2p$ of these ordinary determinants into the first taken, with all its signs positive. A somewhat similar result is shown to hold for determinants of alternate numbers. As an application, let

$$z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)} + \ldots + \frac{a_n}{(x - \alpha_n)(y - \beta_n)},$$

and let (p, q) denote

$$\frac{d^{p+q}z}{\underline{|p}\,\underline{|q}\,dx^p dy^q}.$$

By multiplying the arrays

$$\left\| \begin{array}{l} \dfrac{a_1}{x - \alpha_1} \cdots\cdots\cdots \\ \dfrac{a_1}{(x - \alpha_1)^2} \cdots\cdots \end{array} \right\| \qquad \left\| \begin{array}{l} \dfrac{1}{y - \beta_1} \cdots\cdots\cdots \\ \dfrac{1}{(y - \beta_1)^2} \cdots\cdots \end{array} \right\|$$

we get

$$\left| \begin{array}{ll} (0, 0), & (0, 1) \\ (1, 0), & (1, 1) \end{array} \right| = \sum \frac{a_p a_q (\alpha_p - \alpha_q)(\beta_p - \beta_q)}{(x - \alpha_p)^2 (x - \beta_p)^2 (x - \alpha_q)^2 (x - \beta_q)^2}.$$

Suppose, now, $n = 1$, we get that the primitive of

$$\left| \begin{array}{ll} (00), & (01) \\ (10), & (11) \end{array} \right| \text{ is } z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)}.$$

Similarly, by multiplying,

$$\left\| \begin{array}{l} \dfrac{a_1}{(x - \alpha_1)} \cdots\cdots \\ \dfrac{a_1}{(x - \alpha_1)^2} \cdots\cdots \\ \dfrac{a_1}{(x - \alpha_1)^3} \cdots\cdots \end{array} \right\| \qquad \left\| \begin{array}{l} \dfrac{1}{y - \beta_1} \cdots\cdots \\ \dfrac{1}{(y - \beta_1)^2} \cdots\cdots \\ \dfrac{1}{(y - \beta_1)^3} \cdots\cdots \end{array} \right\|$$

we get that the primitive of

$$\left| \begin{array}{lll} (00), & (01), & (02) \\ (10), & (11), & (12) \\ (20), & (21), & (22) \end{array} \right| = 0,$$

is

$$z = \frac{a_1}{(x - \alpha_1)(y - \beta_1)} + \frac{a_2}{(x - \alpha_2)(y - \beta_2)}.$$

Similar primitives are obtained for differential equations, which are in the form of determinants of higher class. A further application is obtained by taking powers of different invariantive symbols, of which (123) is the simplest for the ternary quantic. The resulting invariants are seen to be determinants of some even class.—A geometrical note, by Mr. R. Tucker.—The President (Major MacMahon, F.R.S., in the chair) made an impromptu communication of a problem, the solution of which he thought would be subsidiary to the sought-for solution of the "stamp folding" problem.

Linnean Society, December 15.—Prof. Stewart, President, in the chair.—The President announced the recent death of Mr. H. T. Stainton, a Fellow and former Vice-President of the Society, and of European reputation amongst entomologists, by whom his loss would be widely felt.—Mr. D. Morris exhibited a series of botanical photographs from the west coast of Africa, and gave some interesting details about the appearance and mode of growth of some of the more remarkable forest trees and plants of that region.—The Secretary exhibited a large collection of photographs of Lichens, very neatly mounted and labelled, which had been recently presented to the Society by Prof. Arnold, of Munich.—On behalf of Mr. George Swainson, of St. Annes-on-Sea, Lancashire, Mr. A. R. Hammond exhibited an aquatic dipterous larva, belonging probably to the genus *Dixa*, of which by means of the oxyhydrogen lantern, with microscopic attachment, a good figure was projected on the screen. He referred to the different views which prevailed concerning the dorsal and ventral aspects of this larva, and pointed out that the tail-plates possessed features which in allied forms were characteristic not so much of the larval as of the pupal stage.—A paper was then read by Dr. Maxwell T. Masters, F.R.S., on the classification and geographical distribution of the *Taxaceæ* and *Coniferæ*, his remarks being illustrated by a specially prepared map, lent by Mr. C. B. Clarke, and by specimens of the fruit and leaves of some of the more notable forms.—Mr. George Brook followed with a paper on the affinities of *Madrepora*, and here again, by means of the oxyhydrogen lantern, an excellent series of coral sections was projected, which illustrated very clearly the author's remarks on comparative structure.—A short note on the abnormal form of the lens in the eyes of an albino rat, by Prof. R. J. Anderson, was read on his behalf by the Secretary. The meeting then adjourned to January 19, 1893.

Zoological Society, December 6.—Dr. St. George Mivart, F.R.S., Vice-president, in the chair.—The Secretary read a report on the additions that had been made to the Society's menagerie during the month of November 1892.—Dr. Hickson read a paper entitled "A Revision of the Genera of the *Alcyonaria Stolonifera*, with a description of one new genus and several new species." The author commenced by stating the grounds upon which it might be considered desirable to retain the suborder Stolonifera, and criticized the views of those who place these Alcyonarians in the suborder Alcyonida. Of the genera that had already been proposed only four could now be retained, namely, *Tubipora*, *Clavularia*, *Cornularia*, and *Sympodium*, and the author proposed to add one more, namely, *Stereosoma*. The genera *Sarcodictyon*, *Rhizoxenia*, *Cornularieila*, *Anthelia*, and *Gymnosarca* must be abandoned, and the species incorporated in the other genera. A description was then given of the new genus *Stereosoma*, a form found on the coast of North Celebes, distinguished from all other Stolonifera by certain characters of its tentacles and by the absolute non-retractability of its polypes. Several new species of *Clavularia* were then described from North Celebes, Diego Garcia, and Australia. This was followed by a summary of all the species of the genus known to science.—Mr. F. E. Beddard, F.R.S., read a description of the convolutions of the celebral hemispheres in certain rodents. The paper referred chiefly to *Dasyprocta Cœlogenys*, *Lagostomus*, *Hydrochœrus*, and *Dolichotis*, being the genera of rodents in which the brains show the greatest development of convolutions.—A communication was read from Prof. Collett, containing a description of a new monkey from S.E. Sumatra, for which he proposed the name *Semnopithecus thomasi*.—Mr. H. J. Elwes read the second portion of an account of the butterflies collected by Mr. W. Doherty in the Naga and Karen Hills and in Perak.

PARIS.

Academy of Sciences, December 19.—Annual Public Meeting.—The President, M. d'Abbadie, gave a brief survey of the life and work of those lost to the Academy by death during the year. Among these were the following members: M. D. D. A. Richet, distinguished for his medical discoveries; M. de Quatrefages de Bréau, the naturalist; M. Jurien de la Gravière, Vice-Admiral under the Empire; M. Pierre Ossian Bonnet, geometrician; Admiral Mouchez, late Director of the Paris Observatory. Foreign Associate: Sir G. B. Airy. *Académicien libre:* M. Lalanne. Correspondents: MM. Gilbert, Abria and Adams. The prizes were awarded as follows: The Grand Prize of the mathematical sciences to M. Hadamard for his solution of the problem of determining the number of primary numbers inferior to a given quantity. One Prix Bordin to M. Gabriel Koenigs for his solution of a problem concerning geodesic lines; another to M. Humbert for his work on hyper-elliptic surfaces. The Prix Poncelet to the builders of the Forth Bridge, Sir John Fowler, and Sir Benjamin Baker; the Extra Prize of 6000 francs to M. Hédouin for his work on the Channel currents; the Prix Montyon to M. N. J. Raffard, civil engineer; the Prix Plumez to M. Augustin Normand, for his geometry of ships. In Astronomy, the Prix Lalande was doubled, and awarded to Mr. Barnard and Mr. Max Wolf; the Prix Damoiseau to M. Radau. for his work on lunar inequalities of long period caused by planets; the Prix Valz to M. Puiseux for his researches on the *equatorial coudé* and other instruments; the Prix Janssen to M. Tacchini for his solar work. Statistics: The Prix Montyon to MM. M.

Bastié and J. Dardignac for works on the population of France and hygienic statistics respectively. Chemistry: The Prix Jecker to M. Bouchardat for his researches on the terebene carbon compounds. Mineralogy: The Prix Vaillant to M. Lacroix for his work on the application of optical characters to the determination of rocks and mineral species. Botany: The Prix Desmazières to M. Pierre Viala for his "Maladies de la Vigne"; the Prix Montagne—1000 francs to M. l'Abbé Hue, and 500 francs to Dr. F. Xavier Gillot for their mycological researches; the Prix de la Fons Mélicocq to M. Masclef for his "Botanic Geography of Northern France." Medicine and Surgery: Prix Montyon—one to MM. Farabœuf and Varnier for work on obstetric medicine, another to M. Javal for ophthalmometry, a third to M. Lucas Championnière for his work on hernia; the Prix Barbier was shared between M. Laborde ("Death by Chloroform") and MM. Cadéac and Albin Meunier ("Alcoholism," &c.); the Prix Bellion to Dr. Theodore Cotel for his work on "The Education of the Senses"; the Prix Lallemand was shared between M. Binet ("Les Altérations de la Personnalité") and M. Durand ("Les Origines Animales de l'Homme"). Physiology: the Prix Montyon to M. Hédon (diabetes) and M. Cornevin (breeding of domestic animals); the Prix Pourat to M. H. Roger for his researches on the inhibitory power of the nervous shock. Physical Geography: the Prix Gay to M. Moureaux (distribution of magnetic elements in France). General Prizes: Prix Montyon, for improvements in unhealthy industries, to M. L. Guéroult (crystal cutting); the Prix Delalande Guérineau, to M. Georges Rolland for his work on the Algerian Sahara; the Prix Jérôme Ponti, to M. Le Chatelier for his researches on dissociation and chemical equilibrium; the Prix Leconte (50,000 frcs.), to M. Villemin for his demonstration of the specific nature and the transmissibility of tuberculosis. The *Comptes rendus* contains a complete list of the prizes to be awarded in the next few years.

BERLIN.

Physical Society, November 18.—Prof. Du Bois Reymond, President, in the chair.—Prof. Neesen gave an account of experiments made with a view to the photographic recording of the oscillation of projectiles. He employed hollow projectiles in whose interior was placed a sensitive plate, illuminated by sunlight through a small opening. During its rotatory flight the ray of light described curves on the plate, from whose position, taken in conjunction with that of the sun, the oscillation of the axis and point of the projectile would be calculated. The results obtained showed that both the axis and point perform oscillatory movements during the flight which are very different from those usually believed to take place. In order to study these more accurately, Prof. Neesen is busy with the construction of some arrangement which may admit of the introduction into the projectiles of sensitive plates which shall not participate in the rotatory motion.

December 2.—Prof. Du Bois Reymond, President, in the chair.—Dr. Du Bois gave an account of experiments made by Mr. Shea in Berlin on the refraction of light in metals, and in connection with this referred to a theoretical treatise which he had recently published on the same subject in conjunction with Dr. Rubens.

Physiological Society, November 25.—Prof. Du Bois Reymond, President, in the chair.—Dr. Treitel gave an account of observations he had made on two snails enclosed in air-tight glass vessels. Dr Ad. Baginski gave an account of a very fatal epidemic among rabbits in the same hutch, in which a post-mortem examination of the dead animals showed a serious affection of the liver and intestinal mucous membrane. The liver was filled with cysts of various sizes, in which, together with coccidiæ, some very remarkable growths were found, which led to very marked changes of the epithelial cells.—Dr. Rawitz made a short preliminary statement of observations on Annulata made during his stay at the biological station of Rovigno, on the coast of the Adriatic. While one species was found to be extremely sensitive to light, and to draw in its tentacles at once when shaded, another closely related species was quite unresponsive, while, on the other hand, it reacted immediately to the slightest touch. The first species was much less sensitive to touch.

AMSTERDAM.

Royal Academy of Sciences, October 29.—Prof. van de Sande Bakhuysen in the chair.—Prof. Engelmann spoke (1) on the influence of central and reflected irritation of the nervus opticus on the movement of the cones of the retina; and (2) on the theory of the contraction of muscles.—Prof. Schoute proved the following theorem:—If $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is the equation of a given ellipse, E, and $f(x_1 y)$ contains the terms of the nth order of the equation of a curve C^n with reference to the same axes. The sum A of the eccentric anomalies a_k of the 2_n points S_k common to E and C^n is determined by the relation

$$e^{iA} = \frac{f(a, ib)}{f(a, -ib)}.$$

He indicated several peculiar cases of this general theorem.—Prof. Kamerlingh Onnes communicated some measurements, by Mr. Leeman, relating to Kerr's phenomenon when reflection takes place at the pole of a cobalt-magnet. The constancy of the difference of phase S, discovered by Dr. Sissingh was confirmed. The measurements agree with the theory of Goldhammer, contrary to that of Drude. Mr. Leeman finds a magneto-optic dispersion in S.

November 26.—Prof. van de Sande Bakhuysen in the chair.—Prof. Schoute continued his communication of October 29, on a general theorem in the theory of plane curves, and corrects a theorem of Laguerre.—Prof. Lorentz dealt with the relative motion of the earth and the luminiferous aether.—Prof. Kamerlingh Onnes spoke of measures on the relation of spark length and difference of potential made by Dr. Borgesius at Groningen with a double bifilar electrometer of his own construction. The differences hitherto found are explained by a correction for pressure and temperature having been omitted. Discharge between two concentric cylinders depends, as Gaugain stated, on the density of the inner one only. Provoking glow discharge on the inner one of two concentric cylinders proves successful in maintaining constant high potentials.

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